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FEDERAL-GRANT RESEARCH PROJECTS OF THE STATE AGRICULTURAL EXPERIMENT STATIONS COMPLETED IN 1940

A typical project outline shows why the study is undertaken, including the economic significance and urgency of the problem, and the specific objectives. It provides a carefully planned procedure or method of attack, an estimate of cost covering personnel and other expenditures, and the agencies participating, including cooperation between departments of the station and with the U. S. Department of Agriculture and other agencies.

Termination of work on a project depends upon the nature of the problem. On most problems of a biological character certain specific objectives may be completed or terminated. Since, however, the biologic factors are constantly changing, research is concentrated on other urgent phases when the immediate objectives to aid agriculture have been accomplished. Certain important objectives in the field of economics can be undertaken and completed within a few years. In this field, likewise, the factors are continually changing and new problems or phases of problems must be studied. Other problems fundamental to agriculture in all fields of science are of long-time character and complex in nature. Their completion or termination is indeterminate.

The record of completion of Federal-fund projects of the experiment stations for the past six years is as follows:

Fiscal Year	Projects Active during year	Projects Completed during year	Percent Completed
1935	2194	266	12
1936	2542	336	13
1937	2644	252	9
1938	2860	286	10
1939	3021	307	10
1940	3185	320	10

The following are examples of projects completed in 1940:

Animal Industry:

1. In the past when difficulty has existed in obtaining satisfactory hatchability of the eggs of domestic fowl on breeding farms in Rhode Island, the procedure has been to increase the level of alfalfa leaf meal in the ration in the hope of improving it. Furthermore, poultrymen for many years in some sections have believed that high levels of alfalfa meal tended to a greater density of yolk color, whereas the consuming population of the East prefers eggs of light yolk color. To settle these moot points the Rhode Island Experiment Station conducted a 4-year investigation (Purnell Proj. 37), which has disproved any relationship between hatchability and density of yolk color. The project has demonstrated that it is possible for poultrymen to produce eggs that will not only meet the requirements of discriminating consumers, but also have a high rate of hatchability. With the factual material of the project available it has been possible to assist local feed manufactures in formulating rations more nearly meeting the requirements of the poultry industry in Rhode Island. In some cases the tonnage of feed thus influenced is great and the project, therefore, has caused a change in feeding practices on many poultry farms of the State. With one manufacturer it has affected a volume of feed of over 300 tons per month. Manufacturers and farmers have been advised to keep their alfalfa level in mash relatively low and in breeding rations to rely on other ingredients to a larger extent than formerly for the vitamin G complex factors.

The results of this project, as they developed, were presented to the New England College Feed Conference Board that meets annually for the formulation of rations recommended by all of the six New England Land Grant Institutions. This study has, therefore, assisted in directing feed practices not only in Rhode Island but throughout the New England States as well.

2. The requirements in B vitamins for swine had not been determined, but recent data seemed to indicate that lack of them might cause pernicious anemia. In a 2-year study by the North Carolina Experiment Station (Barnhead-Jones) of the relationship of the B-vitamin complex to swine metabolism and anemia, a basal vitamin-B-free diet plus thiamin and yeast to make 3 percent of the diet proved adequate. There is no blood-forming (hematopoietic) factor in yeast, and swine adapted themselves to a reduced level of this factor in the diet. On a low-protein, low-vitamin diet, adult swine died of other deficiency symptoms before the production of macrocytic anemia or sprue.

3. To be able to command the highest returns from lamb-fattening rations under different types of farming, it became important to determine the amount of cottonseed meal best suited to supplement hegari fodder and hegari grain, and also how properly supplemented hegari fodder compared with choice alfalfa hay. The New Mexico Experiment Station attacked this problem (Purnell Proj. 44) by purchasing in the fall of each of 3 years 210 New Mexico range feeder lambs, dividing them evenly into 7 groups, feeding them for a period of 83 days on different combinations of the above rations in dry lots, and then shipping by railroad to Kansas City where they were sold on the open market.

These 3-year feeding trials showed that a 0.35-lb. supplement of cottonseed meal promoted as good gains and the greatest economy in feed used of any ration tried, No hegari fodder ration, regardless of the amount of cottonseed meal used, was as good a producer of gain or as economical in feed use as choice alfalfa hay. The determining of these two facts has aided both the dry-land and the irrigated-land farmer, since in the dry-land areas hegari fodder and other sorghum fodders are the principal roughages available. This investigation not only proved that these roughages are useful in lamb-fattening rations but that when supplemented with 0.35 lb. of cottonseed meal the ration is most profitable. Heretofore most feeders had used only 0.25 lb. of cottonseed meal and were thus not obtaining as good results as desired. The irrigated-land farmer is always interested in more uses of alfalfa hay. The fact that in these tests it held an advantage over hegari fodder will show him the possibilities of growing more alfalfa and the advantage in feeding it, thus at the same time increasing his income and improving his land.

4. Information being needed on the most economic feeding methods for dairy cattle under Rhode Island conditions, the State Experiment Station made a 3-year study (Purnell Proj. 18) the results of which were used by the Dairy Commodity Committees of the farm bureaus in the State when preparing the annual program for county extension work, and the information obtained by the study has been used as a basis for current releases through the extension service on dairy farm management. Discussions of the results have also been presented at the annual meeting of the Dairy Herd Improvement Associations, at a meeting of the dairy farmers and feed dealers during Farmers' Week at Massachusetts State College, and over the radio. Furthermore, the methods used in the study were presented at the annual meeting of the New England Research Council, and a member of the Connecticut Station staff interested in a similar study in that State conferred with the Rhode Island Station staff regarding methods used, sources of information, and preparation and use of the data obtained. A manuscript giving the results of the investigation has been submitted for publication.

5. Quality as well as rate of gain must be considered in evaluating rations for turkeys. In a 2-year study (Purnell Proj. 289) aimed to determine how to obtain the best combination of high quality and reasonable cost, the Wyoming Experiment Station tested various kinds of grains for the rations of growing and feeding turkeys. Evaluation of the grain was made not only on the basis of rates of gain but also on the quality of the carcasses and the flavor of the meat as judged by tasting committees. Birds fed corn and wheat, whether for the entire growing period or for the fattening period only, had a better carcass type, were better fleshed, and presented a more suitable market condition. Rye, barley, and oats proved much inferior in these respects. However, all grains proved suitable for fattening, except that a sudden change to rye from a grain mixture decreased grain consumption and slowed growth, evidently because the birds disliked the taste of rye. Yellow corn colored the flesh yellow, while other grains produced a whitish-appearing flesh. A 45-day fattening period prior to marketing proved sufficient to change the type of body fat. Feeding a single grain during the entire growing period and during the 45-day fattening period gave practically the same results so far as hardness of flesh was concerned. Oats produced a softer fat, corn, barley, and wheat the hardest fats, while rye was intermediate in this respect. There was not enough difference in the palatability of the cooked meat to cause one grain to be favored over another. Turkey growers may thus use with confidence any grain which seems best from other standpoints. The final results showed also the way carcasses of birds fed on the various rations stood up in cold storage, 5 months tending to level out any differences in quality observed in the freshly killed birds.

Animal Diseases:

6. An important question has been raised among cattle breeders as to whether herds that have been freed from Bang's disease (infectious abortion) can be reinfected when allowed to run in the same pasture with infected hogs. The Missouri Station in a study begun in 1935 and completed in 1940 found that there is little danger of cows aborting or developing active infection following contact with artificially inoculated hogs under pasture conditions. The experiments point to the conclusion that infected swine, therefore, are not a serious problem in the control of Bang's disease in cattle under average Missouri farm conditions and that when a herd is free of the disease it will probably remain so if proper precautions are taken, regardless of the failure on the part of the Missouri farmer to eradicate the disease from his hogs. The presence of active cases of the disease in these experiments was demonstrated by the fact that negative pigs placed in the pasture with artificially inoculated ones contracted the disease.

7. When using the agglutination test for past or present infection by the bacteria of infectious abortion (Brucella suis and B. abortus), the Missouri Experiment Station found an appreciable number of gilts (in many cases virgin gilts) to show a low blood agglutination titer to this organism. This doubtful reaction was insufficient to definitely label these animals as infected, but raised the question of their possible menace as carriers of the disease to healthy hogs. Following up this problem so important from the standpoint of eradication work, the station, in a six-year study (Adams Proj.3), found that such gilts were never spreaders of infection to negative-reacting susceptible animals, and neither form of the abortion organism could ever be isolated from them. It is thus concluded that although gilts sometimes retain low agglutinating titers against the abortion bacteria, they are not dangerous so far as spread of infection or breeding efficiency is concerned, in a herd otherwise negative to the test. However, such low-titer gilts, as well as negative animals, are susceptible to infection and therefore outside exposure must be prevented. These findings have high significance to hog raisers in general, and for the reduction of losses connected with eradication work in particular.

8. During six years the Florida Station has studied many instances of paralysis and death in cattle on pasture and open ranges. Losses due to the ingestion of heavy indigestible materials, such as dead leaves, Spanish moss, and soggy swamp grass, when green forage is scarce have been avoided by proper feeding and care of the animals during the winter months. Other deaths were traced to botulism resulting from the consumption of portions of animal carcasses that died on the range. These losses ceased when decomposing animal carcass material was collected and burned and the cattle supplied with a mineral supplement as worked out by the Station. The typical clinical and histological symptoms associated with poisoning from grazing Crotolaria spectabilitis have been described.

9. Because of the importance of the problem to the large poultry industry, the Nebraska Experiment Station embarked on a study covering 12 years (Purnell Proj. 167) on the influence of surrounding conditions on the occurrence, spread, and severity of six infectious diseases of poultry due to bacterial or protozoan parasites. The principal purpose was to evaluate hygienic measures, and to gather information in regard to the relation of each of these disorders to a given flock after its exposure to the particular micro-organism causing it.

(a) An attempt to determine whether or not healthy fowls not reacting to serological tests would, by exposure to fowls infected with bacillary white diarrhea (pullorum disease), acquire a positive blood reaction to the disease, yielded negative results, indicating that such exposure had not played a part in the transmission of pullorum disease.

(b) Hygienic measures were found to afford a definitely preventive influence against bacillary fowl typhus infection under exposure to affected birds, 10 deaths occurring under sanitary and 70 under unsanitary conditions. Under the latter conditions outbreaks comparable to those observed on farms took place.

(c) In the transmission and spread of fowl cholera, apparently healthy birds, as carriers, played a dominant part. The benefits of sanitary restrictions were apparently canceled by the intensity and virulence of infection by direct contact among the birds.

(d) Sanitation did not greatly modify the incidence of tuberculosis when tuberculous fowls were introduced. Healthy older birds showed a rather well marked resistance when exposed by direct or indirect contacts. It was found, however, that mature tuberculous fowls constitute a very important reservoir of infection from which poultry yards may be constantly contaminated, and hence should be promptly eliminated.

(e) The determination of coccidial infestation by counts of cysts proved to be a more dependable basis than mortality alone for judging the sanitary fitness of external conditions relative to this protozoan parasite. By using hardware-cloth panels combined with protection of food and water supply against infestation it became possible to reduce the incidence of coccidiosis to a bearable minimum.

(f) It was found that turkey poults can be raised to maturity with a minimum of blackhead, another protozoan disease, when maintained in a yard covered by coarse gravel, with food and water provided in sanitary utensils, and with avoidance of contacts with common fowls. Furthermore turkey poults were raised to maturity in a restricted area covered by hardware-cloth panels without blackhead risk even after poults affected with the disease had been introduced. Chickens and their body wastes are regarded as the fountainhead of blackhead infection. The blackhead hazard was still present in soil two years after chickens had been removed from the lot concerned. In an unsanitary area exclusively occupied by turkeys during six months of each year, blackhead infection progressively declined in the course of seven years until a temporary occupancy by fowls of the lot concerned caused infection to increase progressively.

The various factors concerned in the epidemiology of these six diseases are presented and discussed in detail in a 57-page bulletin reporting upon the results of the investigation.

Economic and Social Studies:

10. Farm woodlands supply an important part of farm income in Carroll County, New Hampshire. Customary methods of marketing farm forest products have been criticized as inefficient and expensive, and cases are cited of such excessive handling that little of the sales price was left for the producer. Any methods by which revenue from such products can be increased should be of great value to farmers in all sections of the State. The New Hampshire Experiment Station conducted a three-year study (Bankhead-Jones Proj. 6) of the production, processing, and marketing of farm woodland products in this country, with results that are applicable to many other parts of northern New England. One reason for the study of this area at this particular time was the interest shown by local farmers in the possibilities for marketing their forest products through a cooperative, a preliminary survey having indicated a majority of them favoring it. These same farmers represented over 60 percent of the quantity of timber of all farmers contacted, and about 90 percent of accessible tracts of those farmers with equipment for cutting and marketing lumber. The results of this research (31-page bulletin) indicated many practical ways of increasing the amount of money farmers receive from the sale of forest products. It was estimated that the county farm income from the sale of woodland products was about $30,000 in 1929, and ways of materially increasing this income by making more efficient the assembling operations and adopting improved production practices were pointed out. The direction in which cooperative efforts appear to have the best chances of success was found to lie in assembling sawlogs, keeping in touch with markets and market conditions, bargaining as a unit for members, and perhaps assisting them in forest management. Better management of the forest resources would make for a more stable agriculture, and more efficient marketing and group action along lines suggested by the study would return more of the sale price to the producer. A program of action was outlined.

11. In order to obtain information of the systems of farming in Iowa with reference to the maintenance of physical resources and the most economic use of both physical and human resources, the State experiment station undertook in a 4-year investigation (Purnell Proj. 520) to analyze and interpret data on variations in cropping systems as related to soil types in each type-of-farming area. This study of the operation of the AAA program in Iowa in 1939 in cooperation with the Bureau of Agricultural Economics indicated the following: (1) Almost 99 percent of the farmers of the State have been in AAA programs at least once in the 6 years of their operation. (2) Of a sampling of 615 farmers, 63 failed to cooperate in the 1939 program, the reasons given showing that about half of them stayed out because of low allotments and low payments for the reduction in grain acreage required. Of the 63 non-cooperators, 41 were tenants. Of the latter, 10 stayed out because their landlords opposed the program, while 9 others were opposed to the AAA in principle. (3) There was a reduction of about 18 percent in corn acreage, a reduction in small grain, an increase in soybeans, and an increase in legumes and other hay and pasture as compared with the period 1929-33. Most of these acreage changes might be attributed to the adjustment program, although there appeared to be a strong upward trend in soybean acreage unrelated to the influence of that program. Two bulletins and seven papers have been published.

12. The increase in tax-financed governmental services and the decline in ability to pay taxes because of lower incomes have in recent years brought about a serious economic problem in most rural areas of Alabama. Tax delinquencies and tax sales have attained enormous levels in some areas and inability and failure to collect taxes have forced many local governmental units to postpone final payment of their obligations. As a result they have either had to issue long-term bonds and tax anticipation warrants, or have had to assume other temporary credit obligations. Revenue for support of local governments is derived principally from general property taxes. The fact that 19,036 rural properties were sold for taxes in the State during the period 1928-33 indicates that many individuals were unable or unwilling to meet their property-tax obligations.

In view of this problem the Alabama Experiment Station has made a five-year study (Purnell Proj.) to obtain information regarding the taxation of rural property and to bring out the merits and injustices of the general property tax system as a source of governmental revenue. It was found that the tax problems of farmers were associated very largely with the general property tax during the period 1848-1935. (1) The general trend of taxes on rural property for this period was upward, the increased demand for governmental services being the principal factor responsible. (2) Property taxes became most burdensome about 1932 when taxes were twice as high, farm real estate values were about the same, and proceeds of farm products were a little over half the 1910-14 level. Consequently, increasing shares of farm cash receipts were required for tax payments. (3) This heavy burden was the leading factor in tax delinquencies on about 60,000 rural properties in 1932, including over a third of the land in the State. (4) Some of the factors found associated with tax sales were decline in incomes during the depression, removal of timber leaving land with less earning capacity, utilization of submarginal land for agriculture under war-stimulated prices, removal of the speculative element from real estate values, and abandonment of farms that had become submarginal because of declining fertility and changing economic conditions. Prices obtained for tax-sale lands in relation to quality were frequently below the prices received in other types of land transfer, due to disposal on a saturated real estate market, to their being considered uneconomical investments, to advertising taxes and costs as minimum bids to set the pace for private buyers, and to the delay of three years before delivery of title, which even then may be set aside by court decision. (5) Moreover, inequalities in the distribution of property taxes appeared among both individual properties and counties as a result of over-assessment and underassessment of farm real estate. Furthermore, inequalities in the assessment of personal property were found to arise as a result of incomplete listings, overassessment, and underassessment. The proportion of the assessed value of all farm property in personal property has tended downward since 1900. Only a small proportion of the tenants listed any property for assessment.

13. The Wyoming Experiment Station has for 11 years been engaged in a study of farm management in the farming areas of the State (Purnell Proj. 187), as distinguished from the range and livestock areas for which projects had already been set up. An important piece of work under this project has been a study of the dairy production in the Star Valley of Lincoln County. The material gathered from these farm management studies serves as the basis for the farm management practices advised and taught by the Agricultural College and Extension Service of the State University. In addition to the published work many conferences have been held with the cooperators in return for the data furnished by them. The published results have been set forth in two extension circulars, a station bulletin, a paper before the Western Farm Economics Association, a series of articles, and summaries in six annual reports of the station, covering such phases of the subject as an economic study of Goshen County, profitable systems of farm and ranch organizations for certain areas of the State, economic studies of irrigated farms in Big Horn County, lamb feeding, and farm management in Wyoming.

14. Since a widespread interest in cooperative marketing and purchasing in North Dakota was actively manifest, whereas but little was known of the many small organizations throughout the State, it was considered most timely to gather data defining the status of cooperatives in this area and to obtain material which might serve as basic information for those contemplating organization of cooperatives or reorganization of those already existing. To supply this much needed information the North Dakota Experiment Station conducted a 5-year investigation (Purnell Proj. 69), the objectives being to ascertain from all available sources the number, kind, age, history, location, and status of all farmer cooperatives in the State and to make a special study of one or more outstanding cooperative institutions. With the assistance of a WPA project information was obtained from the office of the Secretary of State at Bismarck for each cooperative for which records were available, a questionnaire requesting financial and organizational data on cooperative organizations was prepared and circulated, and a survey in conjunction with the Farm Credit Administration was made of the records of each cooperative organization in the State. The information thus obtained was then analyzed (Station Bulletin 578) as regards the extent of cooperative associations in North Dakota, including the number of such associations, number of members and patrons, and volume of business; laws affecting cooperative associations; organization policies; time of establishment; methods of financing; and operating results. For the year 1937 there were 578 active cooperatives with a total of 70,023 members, of which 58,710 were member patrons, and there were 108,574 member and nonmember patrons of these associations. Included were associations for elevators, oil, livestock shipping, creameries, cream shipping, wool pools, potatoes and potato warehouses, cold storage, poultry sales, honey, alfalfa seed, and cooperative exchange. The combined assets of these cooperative associations involved over 10 million dollars. Operation of the associations resulted in total operating expenses of $2,353,907, net gain of $589,846, and patronage dividends of $427,237 were returned to the members. The mass of detailed information on North Dakota cooperatives obtained is analyzed and published in a way not previously presented, and should prove invaluable to all interested in cooperative purchasing and marketing, not only locally but also for general application.

15. To obtain information on recent market legislation and its significance to Iowa families and to serve as a basis for preparing a popular bulletin on certain aspects of consumer education the State experiment station made a survey (Purnell Proj. 627) during 1939-40 of prices of selected commodities in national chain and independent stores in 10 Iowa cities ranging from 10,000 to 60,000 in population. A comparison of grocery prices was made, among stores, of 12 national brands and 19 foods more or less variable in quality. Outstanding in the findings of this first survey are the following: There has been a marked development of supermarkets in the small cities of the State in recent years. A larger proportion of the voluntary chains provided full or part-time service than did the national chains and the 1- and 2-unit independents which were not involuntary chains. In all 10 cities included, the national retail chain units quoted a lower price for the products than did the independent retailers who were reported to be their close competitors. There was, however, a wide variation in the price differential. In one city chain prices were less than 2 percent lower than the independents' prices on the products other than national brands, and in another city they were about 24 percent lower. The range among the cities on the difference in prices of national brands was much the same. Nearly all the independents had a few items the price of which was equal to or lower than that of the same items in the chain. The size of the city appeared to have no bearing on the differences in price between the prices in chain and in independent stores. These were paired with 5 nonservice chain units. The independent stores showed an average slightly higher than that of the chain stores. For the 5 items of green groceries the independents had, however, a lower total price than the competing chains. The general price level in the nonservice independents was considerably lower than the prices in the service independents. The following are some of the types of legislation analyzed for promotion of more enlightened public opinion: Pure Food and Drug Act and its operations; Wheeler-Lee Act giving Federal Trade Commission certain control over advertising; Robinson-Patman Act controlling quantity discounts; Miller-Tydings Act permitting resale price maintenance; chain store taxation; and certain interstate trade interference.

16. For use of North Dakota teachers, organization leaders, extension workers, and others interested in the problems of rural youth and for developing sound programs of procedure, information was needed as to the educational and occupational status, participation in social organizations, and the vocational and social interests of rural youth, 15-29 years of age. This age group has come to be regarded as neglected, and an increasing interest has developed in attempting to solve its problems. Programs of organization have been discussed, but definite procedure has been rendered difficult of establishment because of the scarcity of detailed information bearing on the status, activities, and interests of rural young men and women. In a 3-year study of selected areas, the North Dakota Experiment Station has attacked these timely problems (Purnell Proj. 77). It developed that in spite of the efforts to be of assistance made by numerous organizations and agencies, both private and governmental, the rural youth of the State expressed serious need for more adequate jobs, education, social and recreational facilities, and leadership and guidance. Over and above any consideration of justice and of equal opportunity for all, the fact that disillusioned and bewildered youth have been the tools of totalitarianism in other lands emphasizes the urgent need for early, democratic solutions of their problems. Specific detailed data were obtained for number and distribution of rural youth in the State, marital status, mobility, and economic, educational, and social situation and interests. The data obtained and the analysis made should be of very definite value to the State of North Dakota in general, to the rural population of the State, and to agencies and organizations attempting to assist rural youth there and elsewhere by providing objective information on the subjects studied, as a basis for programs designed to provide more adequate economic, educational, and social opportunities for rural youth. The publications providing this information are being made available to interested agencies, organizations, and the general public.

Field Crops, Pastures, and Ranges:

17. It is important to know more about the performance of potatoes in Colorado under a variety of soil and climatic conditions. Potatoes are an important source of carbohydrates in human diets, and in the near future they may figure more largely in the production of alcohol for fuel and other industrial purposes. Colorado has risen to seventh place among the States in potato production, with possibilities of considerable expansion for food purposes as well as for seed. Such matters as starch content, palatability and culinary quality, together with conditions which influence them, are of great economic value to the potato-growing industry. Unfortunately few definite or well standardized methods have been established for measuring these qualities, and potatoes are still bought on the market largely on the basis of outward appearance. Accordingly, the Colorado Experiment Station undertook a 5-year investigation (Adams and Purnell Proj.) to determine if possible to what extent purely chemical causes have figured in the rise and fall in prominence of the principal potato-growing districts of the State.

Tests with six potato varieties in 12 localities of the State over a succession of years indicated that both heredity and the conditions under which the plants are grown affect the starch content of mature tubers, moisture and sunshine playing the chief part, aside from heredity factors. Starch content rose and fell with total dry matter, so that a very close approximation of the starch content of commercial tubers could be obtained on this basis. Regardless of tuber size starch content increased with maturity of the tuber and oversize, mature tubers usually carried a lower percentage of starch than moderate-sized mature tubers. Under dry-land conditions the later maturing varieties failed to ripen properly and were stunted and low in starch content. Early varieties matured well and ordinarily produced as much starch under dry-land as under irrigated conditions. Full evidence was obtained that both starch content and high yields are conditioned on an ample supply of moisture well distributed throughout the season and particularly in the latter part. In general, irrigated potatoes showed higher starch content and all the 600-bushel per acre yields were in irrigated fields.

Although there was a marked lack of balance in minerals in some of the soils, this was only partly reflected in the character of the tuber ash, indicating some selectivity in the absorption of minerals from the soil. However, the absolute amount and quality of the ash depended more on available moisture than on the amount of available salts in the soil. Mineral shortages were largely confined to a lack or unavailability of phosphorus. Nitrogen appeared to produce smaller, light-colored and thin-skinned tubers; potash applications produced tubers of medium and rather uniform size and shape, starchy and yellowish in color, and also thin-skinned; applications of phosphorus, besides increasing yields, tended to produce rather thick, well-russeted skins, resistant to abrasion. Although the middle planting date (May 18-25) gave the best yields and the most uniform-sized tubers, planting date had but little effect on mineral composition or starch content.

On the basis of this study, the primary causes for the rise and fall in prominence of the potato-growing sections in Colorado must be sought in the presence of plant and soil-borne organisms rather than in chemical and climatic factors. There is growing evidence to that effect in some of the potato diseases now being studied, involving such factors as insect pests, and fungus, bacterial, and virus diseases regarding which full knowledge has not yet been obtained.

18. Southeastern New England is a natural grass-growing region, and in the past considerable Rhode Island bent has been grown for seed production. The amount and kind of fertilizer to use for maximum seed production presented an important problem, since overapplication of nitrogen produced lodging of the plants, caused poor seed yields, and also handicapped harvesting. As a result of a 3-year investigation by the Rhode Island Experiment Station (Purnell Proj. 34), it was indicated that a complete fertilizer analyzing 6-6-1 at the rate of 1,000 pounds per acre produced the maximum pure seed crop of Piper velvet bent, conforming to results with Rhode Island Colonial bent as influenced by the kind and amount of fertilizer. Production of Piper velvet bent on the acre basis is very similar to that of Rhode Island bent, but the return from the sale of the former is much greater per pound and consequently it is of more value as a crop for this region. Growers are now following recommendations based on the experimental work and satisfactory results are being obtained. Another outcome of this work and a benefit to agriculture has been the development of a law and a system of grass seed certification which was initiated last year for the first time. There is a considerable demand for pure seed of Piper velvet bent grass. In 1939 one farmer produced on less than an acre of land 102 pounds of certified seed that was sold for $4 per pound. Several others have become interested in the growing of pure seed to supply the demand. In 1940 several farmers in different areas of the State applied for seed certification, and it is estimated that 14 to 15 times as much certified seed will be produced in 1940 as in 1939, thus indicating a considerable interest and advancement in the industry. An estimate of the total 1940 crop of velvet bent is placed at $7,000, and based on this year's interest it is believed reasonable to estimate that $10,000 would be an annual minimum return in following years from growing seed of this variety in Rhode Island.

19. Use of the range for grazing is the most important enterprise in Wyoming. It is thus very desirable that every effort be made to obtain information which may throw light on how to improve and make better use of these ranges and feed crops, to find out whether there has been a marked change in carrying capacity of the grazing land of the State, and to determine whether the grazing capacity is at present either improving or declining. Opinions are diversified as to what has happend and is happening to the range in various parts of the State, and there are also many theories as to the best way to manage it. However, actual knowledge of what the range was in the past and what was its carrying capacity are very meager, and the first step towards a rational system of range management is to find out exactly what the situation is now in order to measure the various changes that are taking place by the different systems of management. In order eventually to answer these questions the State Experiment Station initiated an investigation 4 years of which are now reported upon (Bankhead-Jones Proj. 269). Special attention was paid to the plant cover and the crop adaptations by soil types, the influence of effective cropping and tillage systems on yields by soil types, the carrying capacity of different vegetative areas, the influence of soil type on plant cover, the time required for natural revegetation on abandoned farm land, and the methods of hastening revegetation on abandoned farm lands. The first phase of the problem being concluded, two bulletins (Sta. Buls. 228 and 229) and two brief summaries (Sta. Rpts. 47 and 49) have been published, and a technical paper is ready for the press covering the work (4 years) prior to revision of the project. Bulletin 229 tells the situation on the Red Desert in 1937-38, and can always be used as a reference point in determining vegetational changes. Already it has been shown that it is meaningless to compare the range on two given years without taking rainfall into consideration, since it has been found that density of native vegetation will change more than 100 percent between drought and wet years. It has been found that the natural revegetation of abandoned farm land in eastern Wyoming is a slow process, and that after 6 years of abandonment the land had only one-third of the grazing capacity of the areas of native vegetation surrounding it. This fact alone will prove important if high prices, high rainfall, and war scarcity should tempt the land owners of the future to plow up the range for grain production.

20. A knowledge of variations in the plant species making up a grassland, as well as of the causes and consequences of such variations, is basic to efficient and scientific land management. The classification of vegetation in western North Dakota is difficult because of the great heterogeneity resulting from variations in topography, soil conditions, wind and water erosion, water penetration, and of the various kinds of transformation in natural vegetation. Definite vegetational types are constantly developing on recently eroded banks, on recent depositions of soil, on saline depressions, on sandy hills and ridges, on abandoned cultivated lands, and on areas depleted by grasshoppers, drought, and overgrazing. In order to determine particularly the relationships between character of grass cover and grazing usage, the North Dakota Experiment Station (Purnell Proj. 46) made a 7-year study of a considerable number of grassland areas in the Little Missouri region in the western part of the State. As a result, the approximate vegetation composition of nine different grassland types has been established and can be applied over a large part of western North Dakota. These types differed chiefly in the plant species concerned, topographic location, thickness of surface layer of dark soil, acidity or alkalinity of the surface layers, total concentration of soluble salts, chemical make-up, soil texture, and soil colloidal content. The findings indicate a definite relationship between soil differences and vegetational differences. Analyses indicated that heterogeneity in soil texture corresponds in a measure with heterogeneity in grassland vegetation types, but other conditions such as topographic position, duration of available soil moisture, depth to the water table, salt concentration, etc., are also important in determining the vegetation types of this region.

The fundamental relationships established by these studies can serve as the basis for greater efficiency in the utilization of farm and range land in western North Dakota. The data obtained have already been used by such agencies as the Farm Security Administration, the Bureau of Agricultural Economics, and the Soil Conservation Service in their planning and administrative work, and special applications of the results have been made by the range management section of the Soil Conservation Service.

21. Information was needed for use in improving the agricultural conservation program through study of ranch practices directed toward more efficient use of the range and the effect of different methods of range management on forage, and on meat and wool production. In line with these objectives the Wyoming Experiment Station conducted a 5-year investigation (Purnell Proj. 255) directed toward determining the best use of agricultural lands of the State under irrigation, dry land farming, and grazing. The latter phase was cooperative for a part of the period with work on land use adjustment of the Bureau of Agricultural Economics, Forest Service, and Agricultural Adjustment Administration. The investigation included the analysis of old data and the collection of new data for use by action agencies. Through these agencies the findings have produced practical results of great value. Short progress summaries were published in the 45th, 48th, and 49th annual reports of the station and in two bulletins. The material is being utilized in other projects and will serve as a basis for future publications by the station.

22. The Coastal Plain area of North Carolina is somewhat limited to acid-tolerant plants, due partly to the cost of lime and the prevalence of diseases on some limed soils. On the lowlands, pastures are largely restricted to native species and carpet grass. According to census data there are insufficient cows within the Coastal Plain section of the State to supply dairy products to its population. Most of the native vegetation is unsuited to improved pastures. The humid grassland areas of the United States are using introduced species, and there has been a great need for studying the adaptability of introduced legumes and grasses if this area of North Carolina is even to approach a grassland agriculture. Accordingly, the State Experiment Station (Bankhead-Jones Proj.) conducted a 4-year investigation in a legume and grass nursery to determine the soil-conserving qualities and the persistence of acid-tolerant legumes and grasses introduced into the region. The original nursery included several genera and many species of legumes. The leads developed from these studies are to be followed up in a Bankhead-Jones project on the cytogenetics and improvement of pasture grasses and legumes.

23. All of the sorghums produce a glucoside which, in the stomach of an animal or in the presence of an acid, gives off the extremely poisonous hydrocyanic acid (HCN). However, it was unknown in how far there were differences in HCN content among strains and whether if present they were heritable, as a basis for developing varieties of low HCN content, and also in how far the available nitrogen or nitrates in the soil affected HCN production in the plant. The Colorado Experiment Station initiated a study of Sudan grass (Adams and Purnell Proj.) attacking the problem from both the breeding and plant nutrition aspects. Although after three years of work it was necessary to hold the project at least temporarily in abeyance, it seemed clear from the results already obtained that there is a difference in the ability of strains to produce hydrocyanic acid, and that the available nitrogen or nitrates in the soil do affect its production in the plant. All the facts thus far gathered indicate that high nitrates during seedling development tend to create a higher HCN level in the plant, a situation of importance from its bearing on tillage problems. The present indications are that both high and low HCN strains of plants at certain stages of growth increase their HCN content as the soil nitrates increase. A relation also seems to be maintained between these two groups of plants, the low strains still remaining lower in HCN than the high strains under nitrate fertilization. If these points remain true under further study it will be highly desirable to continue breeding work for the development of strains of Sudan grass with good forage, yield, drought tolerance, and low HCN habits.

Foods and Human Nutrition:

24. Pinto beans are one of the most important food crops of New Mexico, as well as other regions of the Southwest, especially so in the restricted dietaries of a large group of low-income families. The comparative freedom of these low-income people from the deficiency diseases, especially pellagra, so common in the South is now explained in part by the findings of a 3-years' study by the New Mexico Station (Purnell Proj.). Pinto beans were shown to furnish liberal amounts of three vitamins, B_1 (thiamin), riboflavin, and B_6, and in addition to be good sources of protein, iron, and calcium. These results indicate the danger that may be involved in attempts to change the long-established dietary habits of a group of people unless based on a thorough knowledge of food values. An important contribution of the study which will have application in the investigation of other foods is the finding that cooking greatly increases the riboflavin and vitamin B_6 content of the beans; raw beans contained little or none of these vitamins. The rather common practice of testing only raw foods may lead to unwarranted conclusions and should at least be supplemented by testing their vitamin content in the form in which they are eaten.

25. The nutritional relationship between vitamin-A deficiency and impairment of adaptation of the eye to darkness is well known, but more reliable and easier manipulated tests for this condition are needed. In a 2-year study the Florida Experiment Station (Purnell Proj. 27), in cooperation with the State Department of Public Health, investigated the value of the biophotometer test for dark adaptation as an indication of vitamin-A deficiency in the school children of Sparta, in comparison with the differential leucocyte count of the blood. When the data from both techniques were analyzed it was concluded that the biophotometer test of dark adaptation may be a qualitative measure of vitamin-A deficiency, but that it is not quantitative. With further improvement in its mechanism and use it is believed that quantitative results can be obtained to a degree of accuracy justifying use of this instrument in making examinations of school children. It is considered that this work has given cooperating doctors and nurses a new light on and a better approach to the problem of health in children.

Horticulture:

26. The plant group (genus Rubus) to which blackberries belong is generally conceded to be extremely involved from the standpoint of the factors of inheritance. To obtain information of assistance to horticulturists and breeders in the development of better commercial varieties, the Rhode Island Experiment Station made a 12-year study (Purnell Proj. 22) of the genetics of blackberries the results of which are proving of great value to plant breeders in that considerable knowledge has been gained about the mechanism of inheritance in this group. During the work a great many varieties which gave promise of thornlessness have been eliminated, having been found to transmit the character of thorniness. One variety, Austin Thornless, was definitely determined to cross and self satisfactorily, and to transmit its character of thornlessness. Among the hybrids developed therefrom, certain promising crosses have been grown. Cooperating with the Boyce Thompson Institute, an improved method of germinating blackberry seeds has been made available to future workers in this field. The trailing growth and lack of the tendency to spread by rootstocks in dewberries was found to be dominant over the erect habit of growth and the tendency to spread by rootstocks in the blackberry group.

27. The water culture and sand culture methods of growing plants have long been in use as scientific tools for determining nutrient requirements. Attempts in recent years to apply these methods in the growing of commercial crops have made the study of procedures best suited to practical applications extremely desirable. The Ohio Experiment Station has made a 3-year study (Purnell Proj. 50) revealing that the production of greenhouse crops in inert media such as cinders or gravel, with the plant foods supplied to them by subirrigation, is a practical method which may be safely advocated for commercial culture. The standardization of solutions and methods of application have progressed sufficiently so that a good grower can safely embark on such an enterprise. The initial costs of equipment are high, but if prorated over a period of years will be found as cheap as any of the present greenhouse methods of growing crop plants. The results indicated that greater uniformity of production may be secured with higher quality, and that usually yields are increased. The method has been valuable for determining the best cultural practices in soil and has shown conclusively the need of proper aeration, drainage, and optimum plant food supply. It is reported that gradually the more up-to-date growers are making installations and that the method is spreading and bids fair in the course of time to supplement or even supersede the culture of greenhouse crops in soil. Five papers on the results of this study have been published.

28. Long-established systems of orchard management which involve the growing of cover crops with intensive and frequent cultivation of the soil are rapidly giving way to a sod and mulch system or one or two cultivations a year throughout the orchard area east of the Mississippi River. This decided shift in the course of cultural practice has come about through the research of State experiment stations and the Department. The contribution of a Purnell project of the Ohio Station (1936-40) has played an important part. Contrary to the commonly accepted view that cover cropping builds organic matter in soils, the Ohio investigators found only 1.8 percent organic matter in an orchard where a summer and winter cover cropping system had been followed, while in sod and mulch it averaged 3 to 5 percent. These results have had an important influence in contributing to better control of erosion in hillside orchards, in improving the productive capacity of orchard soils, and in reducing costs of orchard management.

29. For best returns from pecan orchards it was necessary to learn their behavior in relation to the nitrate, total nitrogen, and moisture levels of the soil under different systems of culture. In a 6-year investigation of young pecans (Purnell Proj.) the Alabama Experiment Station kept records on the moisture and nitrate levels at 2-week intervals under 15 different culture systems, and on tree diameter and shoot growth at the end of each year. From the detailed data obtained it was found that moisture affected growth much more than did nitrates, and that there was a much higher correlation of shoot growth with the soil moisture content of the previous than of the current year. However, a favorable moisture content produced a larger tree, and a larger tree in its turn required more moisture. Therefore, a large tree, the result of favorable moisture levels, in time becomes a factor in reducing the soil moisture. Furthermore, shoot growth for a given year was affected more by favorable moisture levels during June and July of the previous year than during April and May, August and September, or during the total period April through September of that year. An unsatisfactory growth during any one year was affected more by the severity of moisture shortage of the previous year than by any other factor examined. Best tree and shoot growth was made on plats mulched with straw, which had very low nitrate levels but favorable or relatively high moisture contents, even during severe drought periods. Poorest tree and shoot growth were made on bermuda sod plats, characterized by very low moisture and nitrate contents. The nitrate levels on plats never receiving commercial nitrogenous fertilization were noticeably lower during the last two than during the first two years of the experiment. Nitrate levels during the fall after turning under of summer legumes were also much lower during the later than during the earlier years, following closely the amount of legumes grown, which in turn was determined by the competition offered by the trees. On the other hand, nitrate levels were maintained on artificial mulch plats at about the same levels during the whole six years of the investigation. These studies were preliminary to a Bankhead-Jones Project on the effectiveness and economic value of certain orchard practices in commercial pecan groves and the behavior of pecan varieties and seedlings relative to ecological factors. The results have proved most interesting, especially with regard to the moisture and nitrate relationships to tree growth, and they give promise also of direct practical application.

30. Apple orchardists have long been confronted with serious losses from limb breakage due to splitting at the crotch caused by crop-overloading and ice storms. Some varieties, such as Northern Spy, tend to form sharp crotch angles which are more likely to suffer from such damage than others, such as McIntosh, which form strong crotches and a more open head. Varieties of the first type usually form high compact heads which are difficult to spray and harvest, but some of them are highly desirable from other aspects and are extensively grown. It was observed that trees of the same variety with open heads were heavier yielding, but it was not clear whether such trees were open as the result or as the cause of heavy bearing. In 1928 the Maine Experiment Station undertook a study (Purnell Proj. 5) to determine this point and to seek ways of developing strong limb crotches. The following procedures were tried out: (1) Grafting buds into the trunks of young trees near the ground for development into the main branches proved not to be a very desirable method of making a bush type of tree. It was concluded that the low heading of vigorous trees is a more effective way of attaining this end. (2) Grafting buds into the trunks of young trees in an upside-down position gave very strong branches, which tended to grow more or less at right angles to the trunk, but they failed to grow as vigorously as normal branches. This method appeared to be of little scientific or practical value. (3) In further tests the main branches of young trees were tethered into a horizontal position each summer by tying them to stakes. Such treatment of about 40 Golden Delicious trees was continued over a period of years to determine whether any relationship exists between tree type and yield. Tree shape was very definitely influenced, resulting in stronger crotches and more nearly horizontal scaffold limbs, but the expense precludes the method for commercial practice. The general conclusions were that untreated trees grew somewhat faster than treated trees, bu the differences were not very significant. Treatments stimulated "sucker" growth, and the additional pruning required may explain the differences in rate of growth of the trees. Treated trees produced slightly more fruit in the early years of bearing, the difference being significant for one or two years, but after that the treatments apparently had but little effect. The results may have been influenced by the variety used, Golden Declisious not being extreme in its tendency to become upright and compact. Results with Northern Spy would probably have been somewhat more pronounced.

Plant Diseases and Insect Pests:

31. Three types of smut are widely distributed on barley in Missouri, their comparative abundance varying from year to year. The Missouri Experiment Station found that covered smut and black loose smut are readily eliminated by chemical seed treatment, but that brown loose smut is not fully controlled by any of the various chemical and hot water treatments tested. These findings led to a search for control in other directions. Investigations (Purnell Proj. 1) on the susceptibility of different barley varieties brought to light two which even under the most drastic conditions became infected only to the extent of about 1 percent. Five years of hybridization work between these and two susceptible but commercially valuable varieties have indicated that the resistance of the two former barleys is similar in nature and due to the action of a single and almost completely dominant genetic factor. Promising hybrid strains of both awned and hooded winter varieties have been obtained by selection from direct and backcross progenies, some of the lines being apparently as resistant to brown loose smut as the resistant parents and with as much winter hardiness and earliness as the susceptible commercial parents. In addition, some of the lines appear to possess agronomic advantages over the commercial parents. About 700 of these resistant selections are now available for further testing. Thus almost complete control of this puzzling disease is assured for the near future.

In connection with this investigation, it was found that ethyl mercury phosphate (in Improved New Ceresan) caused significant increases in the yields of the Early Beardless variety in some seasons but not in others. The evidence seemed to indicate that these increases were due to the protective action on the very small seedlings against root parasites, which are considerably dependent for their inroads on favorable seasonal conditions. Furthermore, none of the seed treatments above noted had any significant effects on the brown spot disease (Helminthosporium sativum), but it developed that the amount of infection was markedly influenced by the date of planting. Sowings made in late August or early September were far more heavily infected than those made later in the season. These subsidiary results are illustrative of the side lights often thrown on issues other than the ones primarily under study and of the opening up of new problems for further investigation.

32. Fusarium wilt is one of the most troublesome and destructive diseases of tomatoes. Considerable progress had been made in its control by the development of wilt-resistant varieties when it was found that resistance tended to break down under conditions especially favorable to the progress of the disease. With temperature and moisture held at the most favorable levels, resistant varieties succumbed almost as readily as susceptible ones. Seven years of intensive work by the Missouri Experiment Station (Adams Proj. 1), involving tests of several hundred collections of seeds, have shown that a strain of the red currant tomato (Lycopersicum pimpinellifolium), from Peru, was nearly or quite immune under all combinations of conditions likely to be experienced. Tests of thousands of plants in various progenies from crosses between this strain and various susceptible commercial tomato varieties proved that this immunity to wilt depends on one dominant genetic factor, the potency of which is not decreased when associated with large numbers of other genetic factors from commercial varieties. Having, by this outstanding investigation, demonstrated the possibility of incorporating the factor for complete resistance in tomato varieties approaching commercial standards for fruit size, shape, and quality, the way has been opened up for complete control of one of the gravest menaces to the tomato growing industry. This phase of the study being completed (with two publications, one of them a monographic report), the final perfection of commercial strains and varieties and studies of the more fundamental bases of resistance and immunity are being continued under new Bankhead-Jones and Adams projects, respectively.

33. The harlequin bug had proved very resistant to the commonly used insecticides. In an investigation covering 11 years (Purnell Proj.), the North Carolina Experiment Station first found that of all the common contact insecticides in use at the time, only a strong soap solution (2 percent) was of value in controlling this sucking insect. Its resistance was shown to be due in part to its very efficient action in closing the breathing pores. The killing effect of the soap solution was influenced by the evaporation rate, being poor under high and very good under low evaporation rates. This phase of the problem had a general application to other insects and the results were published in a technical paper. With the introduction of some of the organic insecticides, tests were conducted on the use of rotenone dusts, satisfactory control being obtained during the summer. During cool weather, however, the effectiveness of these dusts for the harlequin bug were reduced. Thus, there has been continued progress first through the development of a spray that could be used for efficient control of a bug that previously could be controlled only by hand-picking and later the development of a rotenone dust providing a more convenient and less laborious control measure, possessing equal or greater efficiency.

Soils:

34. There was a need for more information regarding the effects of soluble salts on the physical and chemical behavior of Colorado soils, and more specifically for data which would help in the reclamation of large areas in the State which are or may become unproductive as a result of the accumulation of salts in the soil. A 3-year investigation by the Colorado Experiment Station of salt effects on physical or chemical soil properties (Purnell Proj.) has been mainly concerned with the effects of various cations (metallic portion of the salt molecule) and various ratios of these cations on deflocculation, swelling, and reaction (pH) of the soil colloids, the main object being to find a means of control for the flocculating and swelling which are the immediate causes of the sealing up of the pores in poorly drained, alkaline soils, and the consequent prevention of water and air movement thfough them. The information gathered has been of considerable practical use in the Grand Junction area where some of the principles worked out under the project have enabled abandoned land to be reclaimed and brought to a high level of productivity. The problem needs further investigation from the standpoint of soils in the soil relationship of lime salts to other salts, because of their intimate relationship to reclamation on certain soils of the State, and also because information on soils is needed in advance of any attempts at irrigation. However, it has been necessary to hold this project at least temporarily in abeyance, following the work above noted.

35. In order to make surveys of the soil and of soil conservation practices, and to effect a land classification and economic appraisal of the farm land in Tama County, the Iowa Experiment Station (Purnell Proj. 530) undertook in a 4-year study to map the soils, slope, erosion and other physical features of the land in this county, to correlate these with economic data, to segregate the land in various grades on the basis of their productive capacity. The report on the erosion conditions and the map to be issued on the scale used in the field are being prepared by the U. S. Soil Conservation Service. The survey report and map are to be published by the U. S. Bureau of Plant Industry in their regular soil survey series, and the State report will be written when these maps become available. A bulletin on yield tests and land valuation is in process of publication.

Trace Element Studies:

36. In recent years the importance to plant, animal, and human nutrition of minute amounts of certain chemical elements (the so-called trace elements) has become increasingly evident. Much emphasis is placed on the deficiency diseases, and more detailed information is needed in all phases of the subject. The Florida Experiment Station (Purnell Proj. 201) has made an 8-year study to ascertain the chemical composition of the ash of crops grown in the State, with special reference to the more unusual constituents of plants and of the fertilizers used on them. Preliminary results with older methods of qualitative analysis giving unreliable or doubtful results, it became necessary to investigate more suitable procedures. Among those tested the spectrographic method was found to give satisfactory results and the major portion of the work on this project has utilized such procedures. Spectrographic analyses of 64 fertilizer materials for 18 trace elements have been reported upon. The phosphatic materials contained, in general, greater proportions as well as a greater variety of trace elements than did the other groups of materials investigated. Complete chemical and spectrographic analyses of the ash of 7 varieties of citrus have also been made. Citrus juices were found to contain appreciable amounts of manganese and copper, in addition to the elements better known to be of considerable nutritional value. Other elements, not previously reported as present, were strontium, barium, aluminum, chromium, zinc, and occasionally titanium, lead, tin, nickel, and silver. Expanding the work to other fields, a comparison of the results of spectrographic analyses of two limonite samples from New Zealand indicated cobalt to be present in one but not in the other. The cobalt-containing ore was known to be effective in the treatment of "bush-sickness" in cattle, whereas the other was ineffective. A comparison of the results of determinations of the trace element content of wire grasses from "salt-sick", marginal, and healthy areas failed, however, to disclose any significant differences. Spectrographic estimation of trace elements in normal new-born rats showed aluminum, barium, copper, manganese, strontium, tin, and zinc to be present in all animals, while lead and silver were detected only occasionally. The zinc content of the ash of various weeds and volunteer grasses and planted land covers were determined, the data apparently indicating that the weeds and volunteer grasses are able to absorb much larger proportions of zinc than the planted land covers and that they appear to make available sufficient zinc to prevent development of the "white bud" trouble in corn. Chemical and spectrographic analyses for 7 elements commonly present in larger qualities, as well as for 27 trace elements, acid or basic reaction, loss on ignition, and insoluble matter, are reported upon for 89 cultivated and 43 virgin soils from central Florida. None of the elements exhibited as retentive properties as did phosphorus. In all cultivated soils there was found an increased percentage of phosphorus over that in corresponding virgin soils. The trace elements were detected more consistently and usually in greater proportions in the poorly drained soils. Publications have been issued on all these phases of the subject. The findings should prove of inestimable value from the standpoints of plant culture, of animal and human nutrition, and of deficiency diseases in general.

37. Trials with various methods of chemical analysis, with special reference to minute quantities of elements such as the so-called trace elements, having proved inadequate, the Florida Experiment Station (Purnell Proj. 256) in a 7-year technical, chemical study investigated the development of quantitative spectrographic methods, succeeding in working out microphotometer procedures of quantitative analysis for the three elements zinc, copper, and molybdenum which proved accurate to small percentages of error. These methods should prove valuable in analytical studies with reference to the important relations of trace elements to nutrition and to the deficiency diseases of plants, animals, and man.

Agricultural Engineering:

38. Thirteen years ago, when the New York Cornell Experiment Station initiated the study of artificial incubation of the eggs of domesticated birds (Purnell and Bankhead-Jones), little was known about it. It was a transitional period when the "sitting hen" was still the main standby in practice and the hatching industry on a large scale was at its beginning. Since no definite information was available, hatching practices were carried on largely on the hit-and-miss method. The object of this study, therefore, was to obtain a more precise knowledge concerning requirements in the surrounding conditions needed for successful hatching of eggs by artificial incubation. With this idea in mind a thorough survey was made of the influences of temperature, humidity, air composition, and air movement on the development of the embryo in specially assembled, well-controlled laboratory incubators. The results of this series of studies have been reported in 36 scientific papers, in 44 popular journals, and as public addresses. The results were timely and served as a guide to the industry, including both the hatcherymen and the manufacturers of incubators. The research brought forth to hatcherymen recommendations for optimum conditions in the hatching of chickens, ducks, turkeys, and other species of domesticated birds, and to manufacturers suggestions towards mechanical improvements in their incubators. Since the laboratory results were utilized and incorporated into practice as soon as they had been verified under commercial conditions, the studies have been of far-reaching significance in reducing losses encountered in hatching.

39. Tillage is the largest single cost item entering into the production of many crops. Both tillage practices and tillage implement design have developed and progressed largely through the use of trial and error methods, science for the most part not having kept pace with practice in the field of tillage. While an enormous amount of energy is repeatedly expended in seedbed preparation, the basic fact remains that no one can describe in definite, clear-cut terms what soil conditions one should attempt to produce in a given soil in order to obtain a desirable state of tilth. In a 7-year study the Agricultural Engineering Department of the Alabama Experiment Station (Purnell Proj.) undertook to determine the tillage practices producing optimum physical conditions for the germination and growth of common field crops on typical soils of the State. Some results of this study of economic importance are indicated in the following statements: Emergence of plants from the seed sown was most rapid and complete from highly pulverized seedbeds, while poor stands were obtained on extremely cloddy seedbeds. Highly pulverized seedbeds produced small, early maturing plants, while extremely cloddy ones produced large, slowly maturing plants. Highest yields were produced on seedbeds of intermediate degree of pulverization. The quality of cotton fiber was not significantly altered by the extreme of soil pulverization. A close relationship was found between noncapillary porosity of the seedbeds and the total yield of cotton, seedbeds of high noncapillary porosity consistently producing high yielding, early maturing cotton plants.